retain the polished appearance. Coatings are great when applied to small brass museum objects. They can be applied without much trouble, and when the time comes they can be removed and reapplied fairly easily. Not so with a 10 foot high by 6 foot wide first order lens which is 85 percent glass and 15 percent brass.

The decision to polish lens brass should be made only after a close examination of its condition. A highly developed layer of cuprite (the reddish brown corrosion layer often found on copper alloys) can indicate that the lens did not receive periodic cyclic maintenance during the historic period. Cuprite is a rather benign form of corrosion often thought of as a protective form of corrosion. It is only bright brass which can quickly corrode. Can the brass be returned to its former glory? Yes. Does the reddish brown form of corrosion need to be removed? No. Brass treatment and the impact re-polished brass has upon interpretation, historic preservation, and future maintenance should be thoroughly discussed by all affected parties before re-polishing is undertaken.

Future Directions

Conservation treatments are available now which will preserve the beautiful classical fresnel lenses in our nation's lighthouses. Architectural conservators, objects conservators, and historic preservation specialists continue their search for even better materials to improve techniques for treatment in the hope that a classical lens will no longer need to be removed from its tower because it is unstable. If a lens must be removed for other reasons, stabilization methods and improved packing techniques help ensure a safe relocation. In large part, it is the public's keen interest in these historic beacons which is helping to preserve them. Public support of preservation oriented institutions like the Lighthouse Preservation Society, the U.S. Lighthouse Society, and the new National Lighthouse Museum (to name a few), helps ensure that the classical fresnel lens will remain an integral part of lighthouse history.

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Larry V. Bowers

Lighting for Conservation

The National Park Service is the repository for an enormous variety of cultural artifacts. For most of us, the information and knowledge we receive in our visit to an NPS visitor center or museum is directly related to how well we see the art and artifacts presented.

We have learned much over the last 50 years regarding the effect of light on organic materials. Exposure to light energy (photons) induces a variety of chemical reactions, causing structural changes, embrittlement, pigment loss, and finish degradation. The degree of damage produced is the result of the amount of illumination and the length of time an object has been exposed. Ultraviolet light was once thought to be the primary agent of damage. We now know that visible light is nearly as damaging and must be controlled accordingly.

Damage from light is permanent and irreversible. Unfortunately, the only way to prevent that damage is to completely eliminate exposure; an obvious difficulty for parks wishing to display their collections. Complicating that is the fact that exhibits in the National Park Service are often designed as long-term installations, to last perhaps for decades. Under these circumstances it is easy to understand that lighting choices may have a great impact upon the important resources we have on display. And therein lies the problem.

The fundamental question proposed to the conservator becomes: what are the safest lighting levels for paintings, furniture, paper objects, textiles, etc.? From the conservator's perspective, the answer to that question of course has to be zero. With no light, and an otherwise stable environment, we can guarantee that our objects will last a very, very long time.

Selection of a sensitive artifact for display automatically carries with it curatorial responsibility to provide exhibit circumstances which allow the object to be preserved for as long as possible while still on exhibit. Limiting exposure is the only alternative. This can be done in two ways: minimizing light levels or limiting the time an object is on display.

Visitor education is important and a component of successful object lighting. Visitor response can be negative if the exhibit design is poor or if he/she is unprepared for the lighting levels required for conservation. These are legitimate concerns. As we age, the light gathering ability of our eyes decreases, reducing visual acuity. An aging population poses increased demands on the skills of exhibit designers.

Until recently, many designers were under the mistaken impression that it was impossible to satisfactorily light objects at levels which meet conservation standards. Education, and the skillful work of individual lighting designers, has shown that it is possible to meet the standards of both disciplines, though it may take some skill and creativity. A variety of techniques can be employed to increase the perception of light and increase contrast, including selection of background color and providing adequate transition areas for visual acclimatization.

Conventional lighting manufacturers now produce a wide variety of lamps and luminaires that fulfill most museum lighting requirements. Lighting an object well can often be reduced to simply choosing the proper fixture and lamp.

Fluorescent lamps have traditionally been used in older style NPS exhibit cases. Though usually spurned for sophisticated object lighting, this type of lamp does offer a way of providing general non-directional illumination in an exhibit. Consumer demand has had a positive impact on this technology. Fluorescent lamps can now be had in a wide range of color temperatures (K)[1] and several have a color rendering index (CRI)[2] rating of 90 or more, far above older style lamps and well above the museum minimum of 85 CRI. They are certainly cost-effective, with life expectancies sometimes approaching 20,000 hours, an obvious asset if maintenance costs are paramount. If the lamp is selected well and carefully employed, fluorescents can still be useful in certain applications.

Directional lamps are considered superior for object lighting and allow the user to exercise far greater control over both aesthetic and conservation concerns. In recent years tungsten halogen lamps have become the standard for art and artifact lighting because of their ability to produce a crisp white light with a high color rendering index.

Fixture choice is important with price often, though not always, an indicator of quality. It is generally advisable to avoid the track lighting and fixtures in your local home supply store and deal instead with reputable lighting manufacturers who know their products and can offer advice and product continuity. Good quality fixtures usually offer the ability to alter your lighting through the use of accessory filters, spread lenses, barn doors, etc. These enable the user to control the shape, amount, and quality of light and greatly affect the presentation.

Lamps vary enormously and, within a particular style, offer a wide variety of beam spreads, wattages, and capabilities. Your choice of lamp will depend directly on the following:

- Area of coverage desired. This is defined by the beam spread of the individual lamp chosen. Most manufacturers will offer a variety of beam spreads within a given lamp model, ranging perhaps from a wide flood (60°) to narrow spot (10°).
- Footcandle level desired. This is a function of the lumens,[3] or light output, and the beam shape. The difference in the amount of lumens produced by an individual lamp type, from a given manufacturer (e.g., General Electric MR-16) is usually defined by the bulb wattage. For instance, a 25 watt GE MR-16 lamp will produce fewer lumens than a GE 50 watt lamp of the same type. Footcandle levels will also be greatly affected by the beam spread chosen. A more focused beam produces a more intense illumination. A narrow spot lamp may produce three times the footcandle levels on a given surface, from the same distance, as that of a similar flood lamp of the same wattage.
- Quality of light. The color rendering index (CRI) and the color temperature will affect greatly the appearance of the exhibit. Lamp choice may be related to the nature of the objects displayed. With monochromatic objects, CRI and color temperature may be of

little concern. Conversely, polychrome objects may require exact color rendering and a precise color temperature for proper display.

- Special features. Pressure from consumers and government regulation has led manufacturers to offer lamps with an expanded range of features, some of which are useful in exhibits. Some lamps now produce much lower levels in the infrared or ultraviolet parts of the spectrum. We've recently measured MR-16 lamps from one manufacturer, which produced only 5 mW/lumen of UV, very much below the museum standard of 75 mW/lumen.
- Lamp life. Depending on the manufacturer, individual lamps can differ enormously on life expectancy, within a given type. A few years ago most MR-16 lamps were rated at around 2000 hrs. Many MR-16s can be had today with 5000 hr. lamp life, lowering lamp replacement costs and reducing overall maintenance.
- Cost. Similar lamps can vary somewhat in cost from one manufacturer to another and special features may affect the price. The difference may be negligible however in relation to the required effect. A low-UV MR-16 lamp may only cost six to eight dollars and need replacing only once a year. By comparison, an Optivex UV filter for the fixture may cost 10 times that amount.

Where conventional lighting is inappropriate, developing technologies such as fiber optics and light pipes offer greater possibilities to satisfy conservation needs. Fiber optics, a relative newcomer to the field of museum lighting, were once considered an interesting, though not particularly practical, lighting tool. They are not suitable for all object lighting and they are certainly not a replacement for conventional museum lighting. However, as fiber optics offer the possibility of completely eliminating ultraviolet and infrared radiation from the object environment, they represent a viable alternative for lighting our most important artifacts.

The National Park Service has been using and testing fiber optic systems for exhibit lighting for over eight years. Subsequent to our first crude (but successful) attempts, we have installed a small laboratory in the Division of Conservation at Harpers Ferry to test a variety of lighting components. It has allowed us to compare and evaluate some of the leading fiber optic systems and given us a set of standards for application.

Fiber optics have been successfully employed for object lighting at a number of NPS sites, including LBJ, San Antonio Missions, Agate Fossil Beds, Harpers Ferry, and Friendship Hill. Fiber optic lighting systems are also in development for the Declaration of Independence at Independence NHP, and for a White House exhibit of 18th-century crèche figures.

As with any technology, fiber optics embrace both the positive and the negative. They are by no means perfect and should be approached from a thoughtful, educated perspective. Inappropriate application may lead to failure, increased costs, or maintenance problems.

Fortunately, over the last decade we have come a long way toward better integrating the needs of visual access without sacrificing the very objects which enrich our experience.

Recent advances in case design, environmental monitoring, relative humidity control, and exhibit lighting have changed greatly the way objects can be presented in our national parks. With a little knowledge and forethought, park staff can make effective and often cost saving, decisions about artifact lighting and the object environment.

Notes

1 Kelvin (K): the standard unit of measuring the color temperature of a light source. Ordinary household incandescent lamps are rated at 2500°–2800°K, producing a light yellow in coloration and considered “warm.” Tungsten halogen lamps are usually rated 2900°–3400°K.

2 Color Rendering Index (CRI): the degree to which a tested light source accurately renders color compared to a Black Body at the same Kelvin color temperature. Lamps are rated on a scale of 0-100.

3 Lumen: the amount of light flow (flux) through one unit area at distance from a source of one Candela.

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